In-Flight Loading of the Galileo Spacecraft's Attitude and Articulation Control Subsystem Software

by
Craig T. Byrnes
Member of the Technical Staff
Jet Propulsion Laboratory
Pasadena, California

Galileo is a Jupiter-bound spacecraft, built and operated by the Jet Propulsion Laboratory for NASA. Launched in October 1989, the Galileo spacecraft can either spin its entire mass at a controlled rate, called its all-spin configuration, or keep one section inertially de-spun and the other spun, called its dual-spin configuration.

Control of spin rate and spin configuration, attitude determination and control, trajectory corrections and movement of most articulatable parts on Galileo are maintained by the on-board Attitude and Articulation Control Subsystem (AACS). Most electronics in the AACS have redundant units, including its two CPUs, memory arrays, and 1/0 electronics between these elements.

Budgetary and time constraints required that Galileo be launched without the AACS software to increase its spin rate to that needed for successful release of its detachable Probe and spacecraft insertion into Jovian orbit. This software was developed and tested in 1991, and loaded into both memories of the AACS in January 1993. This In-Flight Load (IFL) was the first ever performed on a redundant subsystem of an interplanetary spacecraft.

The length and complexity of the IFL and the interactions with various fault protection algorithms on board presented many operational challenges. For example, it was decided to check both AACS memories for any addresses with failed bits prior to loading the new software. Algorithms unique to Galileo were developed for this purpose. The nature of the IFL required some fault protection to be disabled, but the duration of the activity, due largely to the low 40 bps downlink data rate, demanded judgments be made regarding how much to disable and for what periods of time. Communications between the two AACS memories had to be disabled while different software versions were resident on each.

One major anomaly occurred during the IFL. Swapping AACS memories during the activity uncovered an improper initial value in both the new and old software. This resulted in a high torque being commanded to the de-spun section's articulatable scan platform. Initial analysis and later use of science instruments on the platform showed no adverse effects of this anomaly. Otherwise, the IFL completed successfully.